Creation of Additional Signal Regions to Increase Signal Sensitivity in the Search for Vector-Like Quarks at the LHC

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An analysis is presented on the effectiveness of four new signal regions in the search for vector-like quarks (VLQs) at the Large Hadron Collider (LHC). These new signal regions attempt to use restrictions on large-radius jet mass, a same-sign dilepton requirement, and lower limits on missing transverse energy and the sum of jet and lepton transverse momenta, to increase signal sensitivity. Each possible configuration of the twelve regions – the four new regions together with the eight used in previous analyses by the ATLAS Collaboration – is applied to data files for simulated VLQ masses ranging from 750 GeV to 1400 GeV. To ensure all regions are mutually exclusive, any event that satisfies the conditions of both a new region and an old region is counted in the old region rather than the new. To measure effectiveness, the signal strength, defined as S/v(S+B), where S is the total number of expected signal events and B is the total number of expected background events, is calculated for each configuration. The most effective configuration is signal regions 4, 6, 7, and 11. Compared to the current configuration – signal regions 0-7 – this configuration yields improvements ranging from 41.4% in the M=750 GeV file to 99.2% in the M=1400 GeV file. The next most effective configuration is signal regions 4, 6, and 7, with improvements from 40.6% at the lowest mass to 98.3% at the highest, followed by signal regions 4, 6, 7, 9, and 11, with improvements from 41.4% to 97.5%.

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